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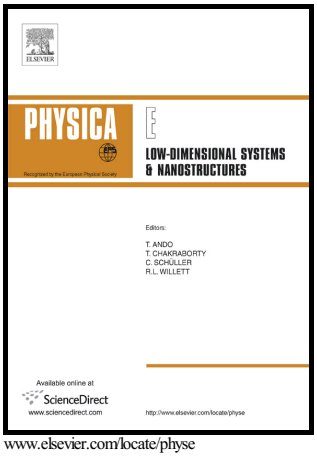

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Electronic properties of zigzag and armchair graphene nanoribbons in the external electric and magnetic fields

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We explore, numerically, some electronic properties of zigzag and armchair graphene nanoribbons under the external perpendicular magnetic field and transverse electric field. Our results, in the magnetic field only, indicate that numerical Landau levels deviate from the Dirac Landau levels formula for higher levels and quantum Hall conductance curve of armchair nanoribbon shows oscillatory behavior in the high gate voltage. In the presence of transverse electric field only, it is shown that the electric dipole moment of zigzag nanoribbon increases abruptly versus the electric field in the range of low-intensity electric fields while for armchair nanoribbon this varies very slowly. This variation in stronger electric fields is staircase for armchair nanoribbon while it is smoothly for zigzag nanoribbon. In the presence of electric and magnetic fields, there are electrons and holes as charge carrier in the same proportions. Conducting electrons make a round current in the half of nanoribbons while conducting holes make a round current in the other half. Electronic vortices, which are static in the presence of magnetic field only, move along nanoribbons in the effect of the transverse electric field. By considering the curve of electric dipole moment versus the electric field, it is found that magnetic field increases the electric susceptibility of nanoribbons in the low-intensity electric fields substantially and creates considerable electric susceptibilities in several higher electric fields. So these indicate that the magnetic field increases the electric sensitivity of graphene nanoribbons.

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Keywords: graphene nanoribbons, Landau levels, edge states, transverse electric dipole moment

I. INTRODUCTION

Over the past decade, experimental and theoretical study of graphene and graphene materials have been main issues in condensed matter physics [1–6]. Graphene nanoribbons (GNRs) are one dimensional graphene with finite width. These graphene derived materials have interesting physical properties which are different from properties of graphene sheet[7–12]. They have also, different properties with each other due to their edges. Zigzag graphene nanoribbons (ZGNRs) are metallic. They have unique properties due to edge states. Armchair graphene nanoribbons (AGNRs) have